Lect. No. 4

Human Physiology

Physiology of the Sensory System

Prof. Dr. Nader Abo-Tubikh

Mazaya University College

Department of Medical Lab Technology

Sensation

There are number of sensations in human body. They can be divided according to their senses to general (surface or deep), special and internal visceral sensations:

I. General Senses

They have vast spread receptors over the whole body. They include:

1. Superficial sensations which include

Touch, Pressure, Pain, Warmth, Cold

2. Deep Sensations which include:

a. Motor sensations which accompany movements of muscles, and joints.

b. Tension sensations which accompany muscles tension.

II. Special Senses:

These have special receptors in a special organs such as:

1. Hearing 2. Vision 3. Balance 4. Taste 5. Smell

III. Visceral Senses

The receptors of such senses are found in the internal viscera

Receptors

Sensory receptors are considered as part of the body that can respond to certain changes and stimulations in the external medium or environment. They can transfer senses in the shape of nerve impulses to CNS which can respond by sending orders to adapt to that effect.

Types of Receptors

1. **Mechano-receptors**

   which include Touch receptor in skin, Sound and Balance receptors in the ears.

1. **Chemo receptors**

   which include Taste receptors of the tounge, smell receptors in the nose and blood osmotic pressure in the hypothalamus and glucose and oxygen receptors …etc.

1. **Thermo-receptors**

   which include warmth & cold receptors in skin.

1. **Electromagnetic radiation receptors**

   which include light receptors in eyes

Types of Receptors

There are two receptors according to the stimulus source and receptor locality:

1. **Extero-ceptors**

Receptors that are affected by external factors such as sound, light, taste, odor, warmth, cold, pressure and pain.

They are found in special organs like eye, ear, tongue nose and skin.

2. **Intero-ceptors:**

Those are found in some internal organs. There are two types:

a. **Viscero-ceptors:**

They are found in the respiratory and digestive organs in addition to bladder and other internal organs. They can produce senses such as of pain, hunger and thirst.

b. **Proprio-ceptors.**

They are found in muscles, joints and tendons. We can sense the muscular tension.

Senses

- Senses continually provide information about surroundings.
- Conversion of a stimulus to a sensation:
  - Stimuli (light, sound, temperature, etc. are changed into an electrical signal or nerve impulse.
  - The signal is then transmitted over a sensory neuron to the brain.
  - The signal is interpreted and man become consciously aware of a sensation.

The Eye

Contains receptors for vision and a refracting system that focuses light rays on the receptors in the retina.

Anatomical Parts

I. Protective parts

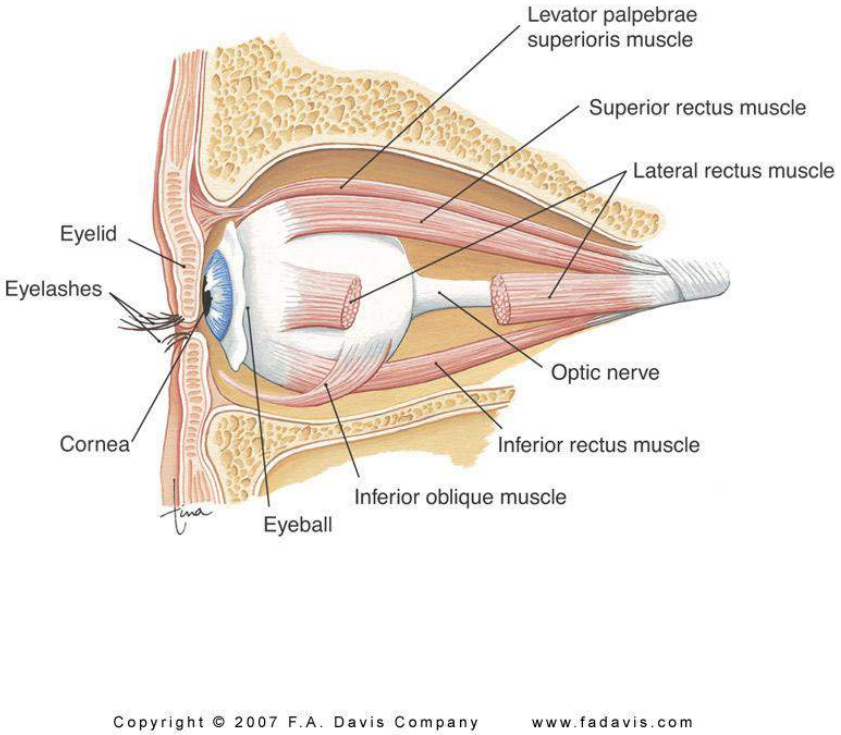
1. Orbit - The eye sits in the orbit formed by the maxilla, zygomatic, frontal, sphenoid and ethmoid bones.

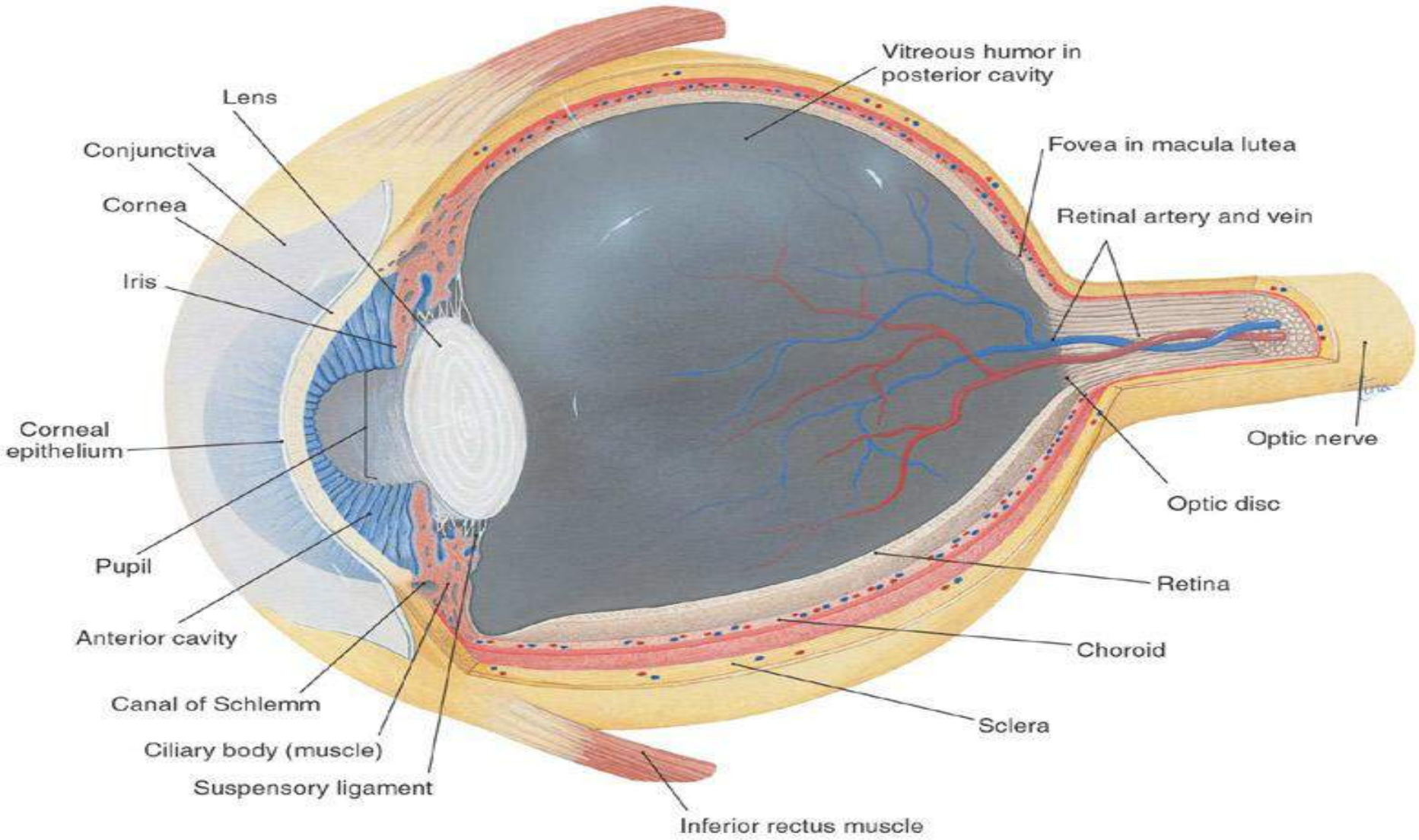
2. Extrinsic muscles - attach the surface of the eyeball to bones.

3. Eyelids – contain skeletal muscle that allow us to close them and totally cover the exterior eyeball.

4. Eyelashes – help to keep dust out of our eyes.

5. Tears – Moisten the eyes.





Anatomy of the Eye

- The human eye is a elongated ball about 1-inch (2.5 cm) in diameter and is protected by a bony socket in the skull.
- The eye has three layers or coats that make up the exterior wall of the eyeball (sclera, choroid, and retina).

Sclera

The outer layer of the eye is the sclera, which is a tough white fibrous layer that maintains, protects and supports the shape of the eye.

The front of the sclera is transparent and is called the **cornea**. The cornea refracts light rays and acts like the outer window of the eye.

Choroid

- The middle thin layer of the eye is the choroid, it is the vascular layer of the eye lying between the retina and the sclera.
- The choroid provides **oxygen and nourishment** to the outer layers of the retina.
- It also contains a nonreflective **pigment** that acts as a light shield and prevents light from scattering.
- Light enters the front of the eye through a hole in the choroid coat called **the pupil**.
- **The iris** contracts and dilates to compensate for the changes in **light intensity**.
- If the light is bright the iris then contracts making the pupil smaller, and if the light is dim, the iris dilates making the pupil bigger.

Choroid

- Just posterior to the iris is the lens, which is composed mainly of proteins called crystallins.
- **The lens** is attached by the zonules to the ciliary body that contains the ciliary muscles that control the shape of the lens for accommodation.
- Along with the ciliary body and iris, the choroid forms the uveal tract.
- **The uvea** is the middle of the three concentric layers that make up an eye. The name is possibly a reference to its almost black color, wrinkled appearance and grape-like size and shape when stripped intact from a cadaveric eye.

The Retina

- The third or the innermost layer of the eye is call the retina. In adult humans the entire retina is 72% of a sphere about 22 mm in diameter.
- The retina lays over the back two thirds of the choroid coat, which is located in the posterior compartment.
- The compartment is filled with **vitreous humor** which is a clear, gelatinous material.
- Within the retina there are cells called rod cells and cone cells also known as photoreceptors.

The Retina
Rod and Cone Cells

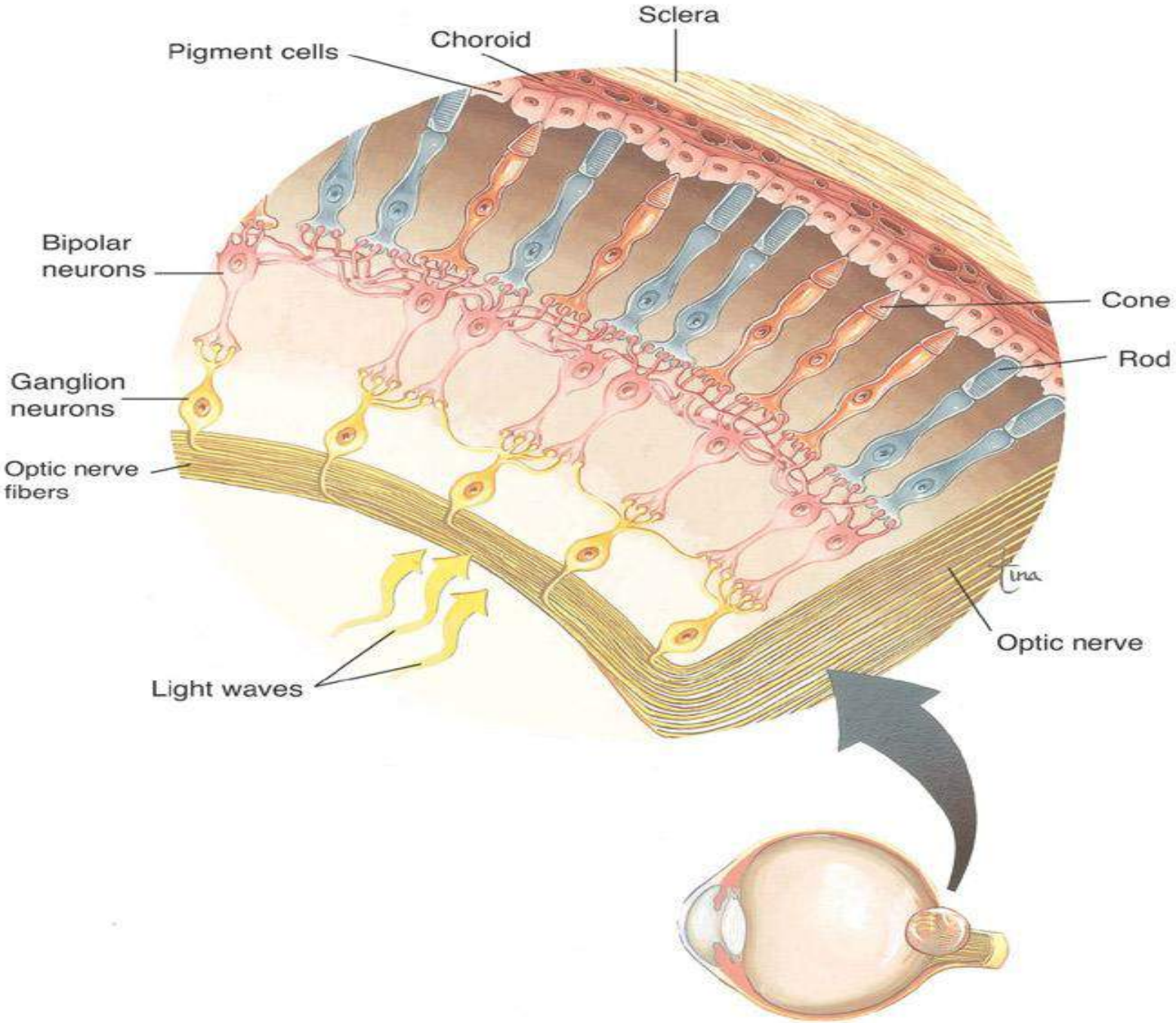
- The rod cells are very sensitive to light and do **not see color**, that is why when we are in a darkened room we see only shades of gray.
- The cone cells are sensitive to different wavelengths of light, and that is how we are able to tell different **colors**.
- It is a lack of cones sensitive to red, blue, or green light that causes individuals to have deficiencies in color vision or various kinds of color blindness.

The Ratina

- At the center of the retina is the **optic disc**, sometimes known as "the **blind spot**" because it lacks photoreceptors.
- It is where the optic nerve leaves the eye and takes the nerve impulses to the brain.
- The cornea and the lens of the eye focuses the light onto a small area of the retina called the **fovea centralis** where the cone cells are densely packed.
- **The fovea** is a pit that has the highest visual acuity and is responsible for our sharp central vision - there are no rods in the fovea.

Retina's simplified axial organization.

- The retina is a stack of several neuronal layers. Light is concentrated from the eye and passes across these layers (from left to right) to hit the photoreceptors (right layer).
- This elicits chemical transformation mediating a propagation of signal to the bipolar and horizontal cells (middle yellow layer).
- The signal is then propagated to the amacrine and ganglion cells.
- These neurons ultimately may produce action potentials on their axons.
- This spatiotemporal pattern of spikes determines the raw input from the eyes to the brain.



Photoreceptors

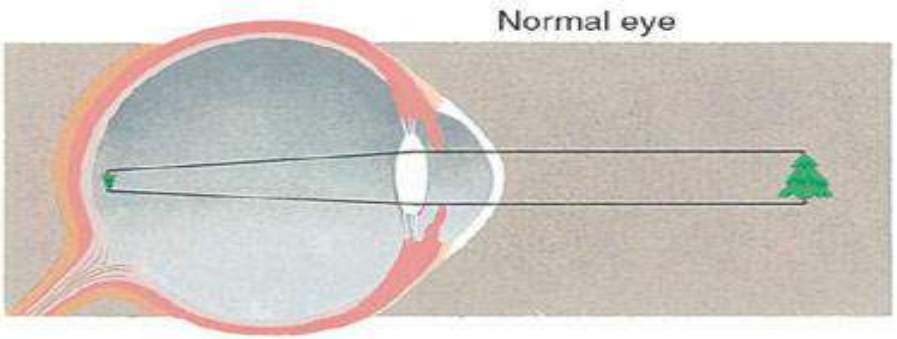
- A photoreceptor, or photoreceptor cell, is a specialized type of neuron found in the eye's retina that is capable of phototransduction.
- More specifically, the photoreceptor sends signals to other neurons by a change in its membrane potential when it absorbs photons.
- Eventually, this information will be used by the visual system to form a complete representation of the visual world.
- There are 2 types of photoreceptors: **rods** are responsible for scotopic, or night vision, whereas **cones** are responsible for photopic, or daytime vision as well as color perception.

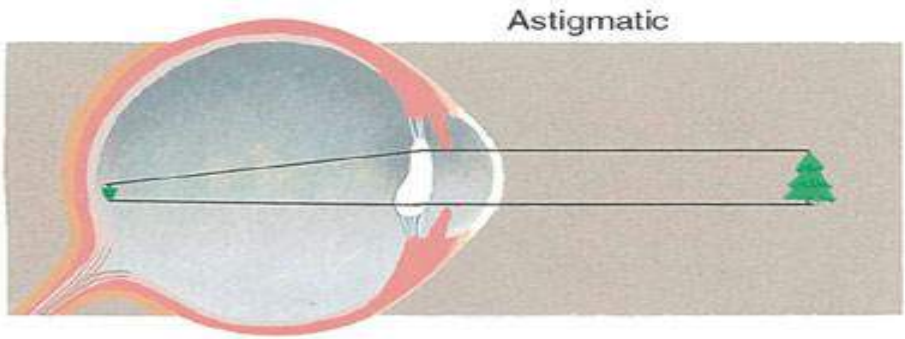
How we see an object

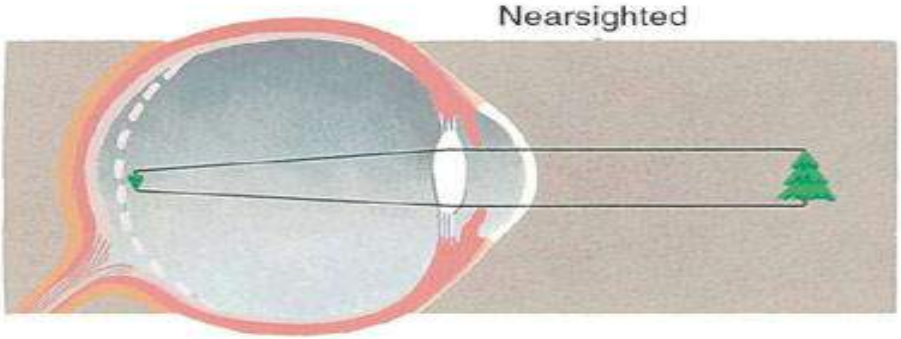
1. The light rays enter the eye through the cornea (transparent front portion of eye to focus the light rays).
2. Light rays move through the pupil, which is surrounded by Iris to keep out extra light
3. Light rays move through the crystalline lens (Clear lens to further focus the light rays)
4. Light rays move through the vitreous humor (clear jelly like substance)
5. Then, light rays fall on the retina, which processes and converts incident light to neuron signals using special pigments in rod and cone cells.
6. These neuron signals are transmitted through the optic nerve,
7. The neuron signals move through the visual pathway - Optic nerve > Optic Chiasm > Optic Tract > Optic Radiations > Cortex
8. The neuron signals reach the occipital (visual) cortex and its radiations for the brain's processing.
9. The visual cortex interprets the signals as images and along with other parts of the brain, interpret the images to extract form, meaning, memory and context of the images.

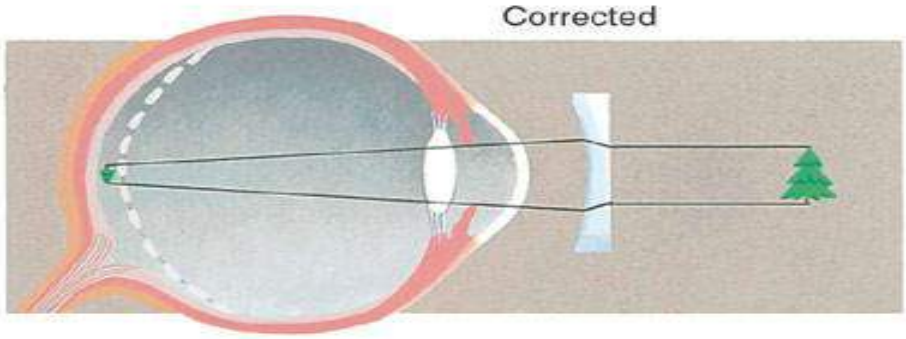
Focusing Problems

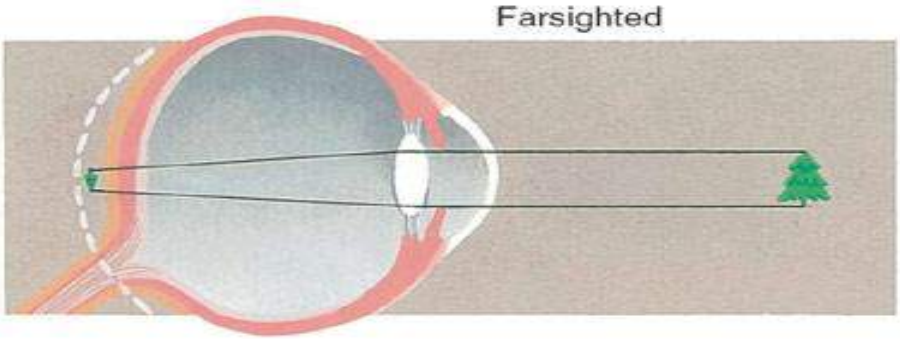
- Presbyopia – “old sightedness” or “short arm syndrome”. Ciliary bodies lose their elasticity and can no longer change the shape of the lens to bring near objects into focus.
- Myopia – nearsightedness, image focuses in front of the retina rather than on it, eyeball is elongated. Corrected by glasses, contacts or radial keratotomy (Lasix).
- Hyperopia – “farsightedness”, image focuses behind the retina, produces a fuzzy image. Corrected by lenses.
- Astigmatism – refraction error – fuzzy image, irregular curvature of the cornea or lens, requires special lenses to correct (Toric lenses) or contacts.

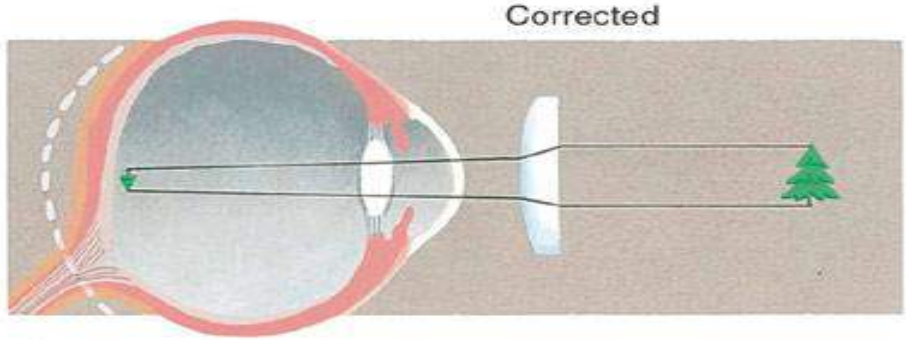






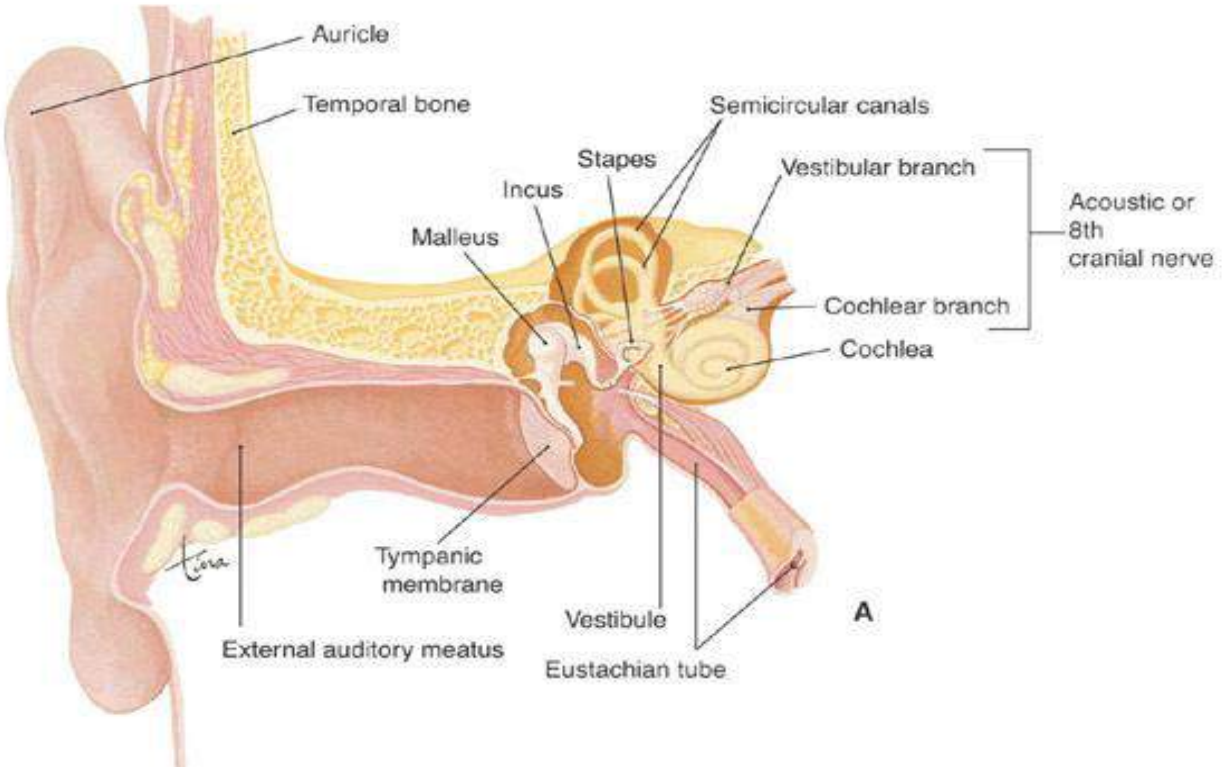






The Ear

It is a sense organ associated with hearing and equilibrium and balance. It composed of 3 main parts: External, Middle and Inner Ear



Anatomical parts
External Ear

It consists of:

1. Pinn: it works like antenna to collect sound waves and direct them towards the middle ear.
2. External Auditory canal – a curving tube about one inch long; extends into the temporal bone and end at the tympanic membrane (eardrum). It protects the tympanic membrane from external collision.

The Middle Ear

Tiny epithelium lined cavity which is hollowed out of the temporal bone. Tympanic membrane – separates the external and middle ear and vibrates when sound waves strike it.

The middle ear contains three tiny bones called ossicles (bones) transmit sound waves. (1. Malleus – 2. Incus –3. Stapes) They are connected with the tympanic membrane.

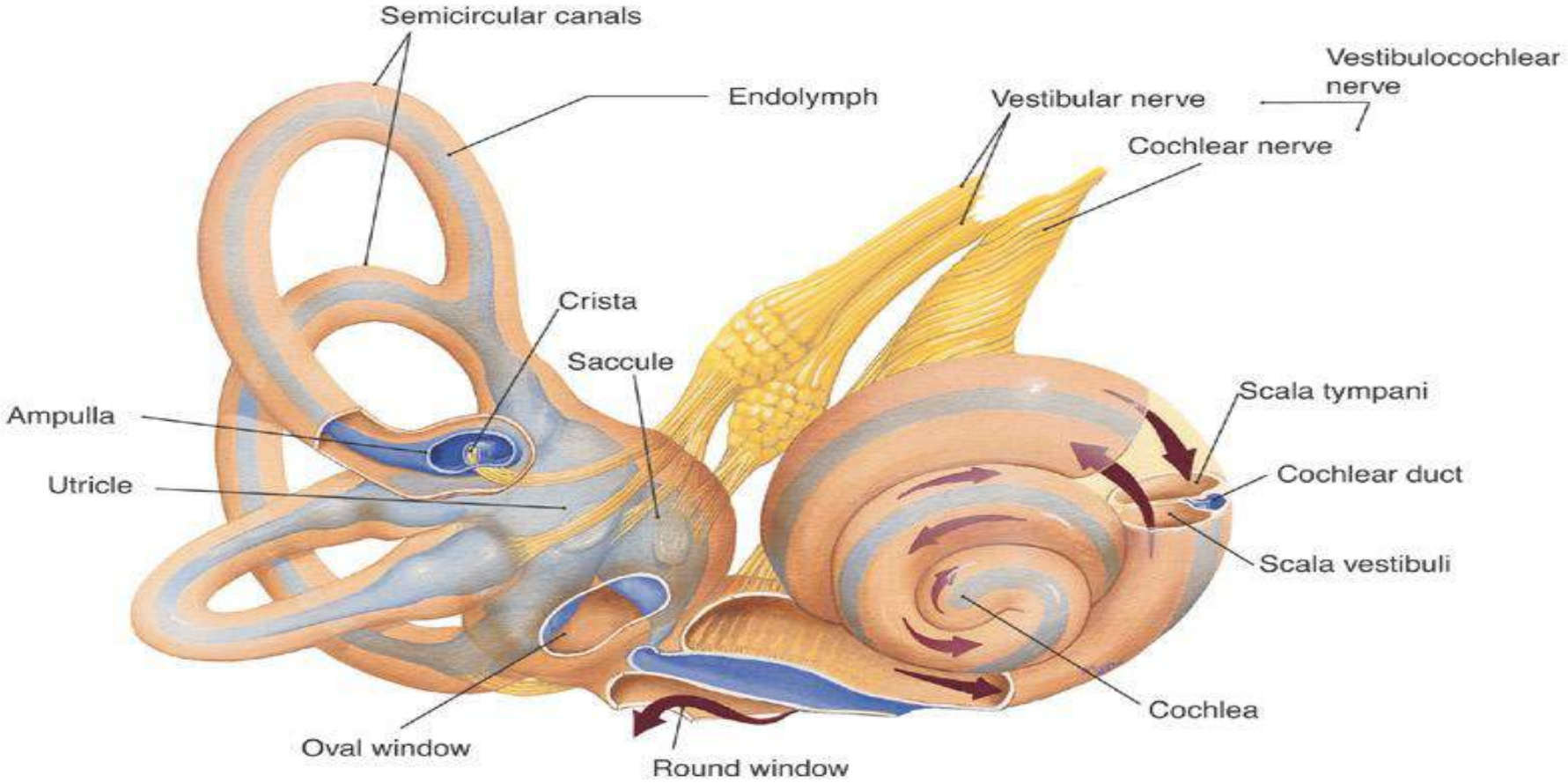
The middle ear also contains the Oval Window which separates the middle ear from the inner ear and Eustachian tube which connects the throat with the middle ear; allows air to enter and leave the middle ear which equalizes pressure.

Inner Ear

It contains mechanoreceptors that are activated by vibration and generate nerve impulses that result in hearing and equilibrium.

The 3 spaces of the inner ear are called the bony labyrinth and contain fluids called perilymph and endolymph.

1. Semicircular Canals – contain the crista ampularis which is a specialized receptor that generates a nerve impulse when you move your head. Receptors for equilibrium.
2. Cochlea – snail shell; contains the Organ of Corti which holds the receptors for hearing (hair cells). As the hairs bend (vibration) they generate an electrical impulse.
3. Vestibule – membranous sacs adjacent to the oval window and between the semicircular canals. Contains receptors for equilibrium.



Hearing Sequence

- The pinn receive the sound waves and direct them towards the external auditory canal which generate a pressure on the eardrum.
- Sound waves cause the eardrum to vibrate, and this movement is transmitted and amplified by the ear ossicles.
- Movement of the stapes against the oval window causes movement of fluid in the inner ear which generates electrical impulses.
- Mechanoreceptors in the inner ear that are activated by vibration will generate nerve impulses that result in hearing and equilibrium.